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BECKMAN

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TECH 350 AND TECH 360

Digital Multimeters

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Beckman Instructions 3000-940-112-A

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TECH 350 and TECH 360 DIGITAL MULTIMETERS OPERATOR'S MANUAL

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Beckman Instruments, Inc. • Electro-Products Group/Instrumentation Products • Fullerton, CA 92634

Beckman Instruments, Inc. Fullerton, CA 92634
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WARRANTY

ONE-YEAR LIMITED WARRANTY

The Series 300 Digital Multimeter is warranted in its entirety against any defects of material or workmanship which develop for any reason whatsoever, except abuse, within a period of one (1) year following the date of purchase of the Multimeter by the original purchaser. This warranty is extended by Beckman Instruments, Inc. (Beckman), only to the original purchaser or original user of the Multimeter, who must, as a CONDITION PRECEDENT TO WARRANTY COVERAGE AND PERFORMANCE THEREUNDER BY BECKMAN, complete and return the Warranty Registration Card, received on purchase of the Multimeter.

In the event a defect develops during the warranty period, Beckman will, at Beckman's election, repair or replace the Multimeter with a new or reconditioned model of equivalent quality. In order to obtain performance of any obligation of Beckman under the warranty, the original purchaser or original user must return the defective Multimeter, postage prepaid, along with a handling charge of $3.00 to:

Beckman Instruments, Inc.
210 S. Ranger Street
Brea, CA 92621
Attention: Customer Service

or to any other Beckman Service Center.

In the event of replacement with a new or reconditioned model, the replacement unit will continue the warranty period of the original Multimeter. Replacement units will be returned by air, typically with only two (2) working day turnaround at the Service Center.

ANY IMPLIED WARRANTIES ARISING OUT OF THE SALE OF THE SERIES 300 MULTIMETER, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE LIMITED IN DURATION TO THE ABOVE-STATED ONE (1) YEAR PERIOD. BECKMAN SHALL NOT BE LIABLE FOR LOSS OF USE OF THE MULTIMETER OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, OR ECONOMIC LOSS OR FOR ANY CLAIM OR CLAIMS FOR SUCH DAMAGE, EXPENSES OR ECONOMIC LOSS.

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This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

*Prices are subject to change without notice.

BECKMAN INSTRUMENTS, INC.
Fullerton, California

Dear Customer:

Congratulations on the purchase of your new Beckman Digital Multimeter! Beckman Instruments, Inc., a leading international manufacturer of laboratory analytical instruments, process instruments and precision components, has extended its knowledge and skills into the production of the Series 300 Digital Multimeter. Because of the time and care taken in the design and manufacture of your Multimeter, we are sure that you will enjoy the use of it for many years to come.

Beckman Instruments, Inc.

CONTENTS

Section	Title	Page
ONE	**INTRODUCTION**	1
1-1	TECH 350	3
1-2	TECH 360	3
TWO	**SPECIFICATIONS**	5
2.1	General	5
2.2	DC Volts	6
2.3	AC Volts	7
2.4	DC Current	8
2.5	AC Current	9
2.6	Resistance	9
2.7	Diode Test	10
2.8	Insta-Ohms Quick Continuity Indicator	11
2.9	Temperature	11
THREE	**PREPARATION FOR USE**	12
3.1	Unpacking and Inspection	12
3.2	Installation	12
3.3	Instrument Familiarization	12
3.4	Initial Checkout	15
FOUR	**OPERATING INSTRUCTIONS**	18
4.1	Warnings and Precautions	18
4.1.1	Warnings	18
4.1.2	Precautions	18
4.2	Overload Indication	19
4.3	Voltage Measurements	19
4.3.1	DC Voltage	19
4.3.2	AC Voltage	19
4.3.3	True RMS Measurements (TECH 360)	20
4.3.4	Application Note	20
4.4	Current Measurements	23
4.4.1	DC Current	23
4.4.2	AC Current	23
4.5	Resistance Measurements	24
4.6	Diode and Transistor Test Measurements	24
4.6.1	Diode Tests	25
4.6.2	Transistor Junction Tests	25
4.6.3	Transistor Beta Test	26
4.7	Continuity and Capacitor Checks	27
4.7.1	Continuity Checks	27
4.7.2	Capacitor Checks	28
4.8	Decibel Measurements	29
4.9	Temperature Measurements	29

Section	Title	Page
FIVE	**THEORY OF OPERATION**	31
5.1	General	31
5.2	Overall Functional Description	31
5.3	Block Diagram Analysis	36
5.3.1	Input Protection Circuitry	36
5.3.2	Input Conditioning Circuits	36
5.3.3	Multiprocessor Chip	39
SIX	**MAINTENANCE**	41
6.1	Warranty Statement	41
6.1.1	Warranty Replacement	41
6.1.2	Non-Warranty Replacement	41
6.1.3	Shipping Instructions	41
6.2	Maintenance Procedures	42
6.2.1	Cleaning Case and Window	42
6.2.2	Battery Replacement	42
6.2.3	Fuse Replacement	44
6.3	Calibration	45
6.3.1	Calibration of TECH 350	45
6.3.2	Calibration of TECH 360	46
6.4	Troubleshooting	47
6.4.1	Service Manual	48
6.5	Instrument Storage	48
SEVEN	**ACCESSORIES**	53
7.1	Vinyl Carrying Case (DC-206)	53
7.2	K-Type TC Probe (TP-254) & K-Type TC Wire (TP-255)	53
7.3	High-Voltage Probe (HV-211)	53
7.3.1	High-Voltage Probe Specifications	53
7.3.2	Operation with High-Voltage Probe	54
7.4	RF Probe (RF-221)	54
7.4.1	RF Probe Specifications	54
7.4.2	Operation with RF Probe	54
7.5	AC Current Clamp (CT-231)	55
7.5.1	AC Current Clamp Specifications	55
7.5.2	Operation with 150A AC Current Clamp	55
7.6	AC Current Clamp (CT-232)	56
7.6.1	AC Current Clamp Specifications	56
7.6.2	Operation with 1000A AC Current Clamp	56
7.7	Deluxe Test Lead Accessory Kit (DL-243)	56

ILLUSTRATIONS

Figure	Title	Page
1	Positioning the Tilt Bail	14
2	Operating Controls, Indicators, and Connectors	15
3	Typical Waveform Crest Factors	22
4	Placement of Leads in Respect to Anode and Cathode	25
5	Test Fixture for Transistor Beta Measurement	26
6	Display of Overload Symbol	27
7	Display of Insta-Ohms Quick Continuity Indicator (Ω)	28
8	Display of Insta-Ohms Quick Continuity Indicator (Ω)	28
9	Decibel Conversion Chart	30
10	Simplified Block Diagram TECH 350	32
11	Simplified Block Diagram TECH 360	33
12	Schematic Wiring Diagram of TECH 350	34
13	Schematic Wiring Diagram of TECH 360	35
14	True rms Converter Block Diagram	37
15	Input Conditioning Circuit for Resistance Measurements	38
16	Rear View of Multimeter	43
17	Multimeter with Top Rear Housing Removed	44
18	Equipment Required for Calibration	45
19	Components Locator for TECH 350	49-50
20	Components Locator for TECH 360	51-52

The Series 300 Digital Multimeters are completely portable, 3½-digit Multimeters designed for use by the engineer, technician, and hobbyist who demand an instrument that is accurate, reliable and always ready for use. Equipped with seven functions and 30 ranges, each test position is quickly and easily selected with a simple turn of the single selector switch. Small enough to fit in most attache cases and equipped with a multiposition tilt stand, these instruments are equally suited for design engineering, production testing, field servicing, and industrial maintenance applications.

In addition to the features described above, all models also offer two particularly useful, yet uncommon digital multimeter features — Insta-Ohms® Quick Continuity Indicator and 10-amp ac/dc current measurement capability. With Insta-Ohms, circuit shorts can be traced and other continuity checks can be made more quickly and easily than ever before possible with a digital multimeter! It can even be used to troubleshoot small-valve capacitors.

The TECH 360 has the added capability of measuring both ac voltage and current in true rms. True rms permits accurate measurement of even the nonsinusoidal waveforms typically found in switching power supplies, motor speed controllers, SCR regulators, and digital systems. The front panel switch of the TECH 360 permits direct measurement of either the total (ac + dc) or (ac only) rms voltage value of complex or simple ac waveforms.

The TECH 350 and TECH 360 include all of the following features as standard:

SUPERIOR RELIABILITY

To ensure high instrument reliability, Beckman designed a custom CMOS large-scale integrated circuit to eliminate most discrete components. Since all active multimeter functions are performed by this one integrated circuit, the total number of electronic parts in the basic instrument has been reduced. Reliability is further enhanced by 100 percent burn-in of each instrument and complete factory test of every function and range.

GUARANTEED LONG-TERM ACCURACY

Specified accuracies are guaranteed for a full year with a single calibration adjustment on the 350 and only five

adjustments on the TECH 360. Long-term accuracy is assured through the use of an extremely stable band-gap reference element and Beckman thin-film resistor networks.

RUGGEDNESS
Beckman Multimeters are designed to give years of trouble-free operation under heavy-duty use. The display and single rotary switch are both recessed to prevent damage while in a tool box or on the job. The case has been designed to keep out dirt, dust, and fluid contaminants that can cause malfunctions in other multimeters.

OVERLOAD PROTECTION
All inputs are protected against continuous overload conditions that may result from the measurement of unknown signals or from operator error. Also, all voltages ranges are protected against voltage transients up to 6kV, 10 μseconds.

EASE OF USE
Human engineered in every way to make the instruments easy to use. A single power switch turns on the power while the function/range knob selects both function and the desired range. The Liquid Crystal Display (LCD) is easy to read both indoors and outdoors, even in direct sunlight.

IN-CIRCUIT RESISTANCE MEASUREMENTS
All resistance ranges, except the 20Ω range, are low-power ohms which allow accurate measurements of in-circuit resistance. Because test voltages are held to less than 250mV, accurate measurements may be made even in circuits where resistors are directly shunted by typical silicon diodes and transistors.

LOW OHM MEASUREMENTS
The low ohm function allows accurate (±.01Ω) measurements from 0Ω to 20Ω. The knob on the underside of the front panel allows the operator to zero out the lead resistance measuring on the 20Ω range.

AUDIBLE CONTINUITY
No longer do you have to watch the meter while trouble-shooting circuits. The switch-selectable continuous audible tone indicates continuity quickly and easily.

DIODE TEST FUNCTION
A special diode test function allows accurate measurements of forward voltage drops across diodes and transistor junctions, even in circuits where simi-conductors are directly shunted by resistors.

BATTERY LIFE
Six heavy-duty (zinc-chloride-) D size batteries provide up to 12 000 hours (eighteen months) of continuous instrument operation. Under typical use, a battery should last four years. Because of the long battery life, replacement batteries should be alkaline batteries only.

LOW BATTERY INDICATOR
The decimal point begins to blink when approximately 10% of battery life remains.

VERSATILE
Perfect for field, lab, or home use. Small, lightweight, and completely portable, it has a handy tilt bail for easy positioning and antiskid pads to keep it in place.

COMPLETE AND READY TO USE
Instruments are shipped with batteries and fuses installed. Just remove the instrument from the box, it is ready to use. Also included is a spare fuse, test leads, and a complete operation manual.

1.1 TECH 350
The TECH 350 has all the features just described, including the Insta-Ohms (audible and visual) Quick Continuity test function and 10-amp current ranges and has an accuracy of ±0.1% of reading dc volts.

1.2 TECH 360
The TECH 360 has all the features just described, including the Insta-Ohms Quick Continuity test function and 10-ampere current ranges plus the capability of measuring ac signals in switch-selectable true rms (ac + dc and ac only) and has an accuracy of ±0.1% of reading in dc volts. In addition the TECH 360 has direct-temperature reading capability via a fully compensated K-type thermocouple plug. Accuracy is ±4 °C on measurements from −20°C to 300°C and ±3% rdg from +300°C to 1265°C (not including thermocouple errors).

NOTE

The symbol ⚠ on the front panel of the instrument is an international symbol meaning "REFER TO OPERATING INSTRUCTIONS." Warnings and precautions to avoid personal injury and instrument damage are listed in Paragraph 4.1.

Specifications are subject to change without notice.

2.1 GENERAL

The following specifications apply to the TECH 350 and TECH 360.

OPERATING TEMPERATURE RANGE
0°C to +50°C

STORAGE TEMPERATURE RANGE
−40°C to +65°C with battery removed

DISPLAY
3½-digit liquid crystal display (LCD) with a maximum reading of 1999

POWER
Six heavy-duty (zinc-chloride) D size batteries.

BATTERY LIFE
Zinc-Chloride: 12 000 continuous hours, nominal
Under Typical Usage: four years.

LOW BATTERY INDICATOR
Decimal point blinks with 10% battery life remaining.

SHOCK AND VIBRATION
Meets MIL-T-28800 specifications

RELATIVE HUMIDITY
0% to 80%, 0°C to 35°C; 0% to 70%, 35°C to 50°C

TEMPERATURE COEFFICIENT (EXCEPT TEMPERATURE ACCURACY SPECIFICATION)
Less than 15% of applicable accuracy specification per °C (0°C to 20°C, 30°C to 50°C)

TEMPERATURE COEFFICIENT FOR TEMPERATURE ACCURACY SPECIFICATION
±(0.015% reading + 0.08°C)/°C

MAXIMUM COMMON-MODE VOLTAGE
1500Vdc or peak ac

DIMENSIONS
7.00 inches (17.8cm) long x 8.5 inches (23.6cm) wide x 3.4 inches (8.6cm) high

WEIGHT
58 ounces (1647 grams) including batteries

CALIBRATION
Accuracy specifications guaranteed for one (1) year, at 25°C ±5°C operating ambient temperature

MEASUREMENT RATE
Four measurements per second nominal

CASE
High-impact ABS plastic, fire retardant

INSTRUMENT INCLUDES:
1. 6 heavy-duty D size batteries
2. Spare fuse
3. Safety test leads
4. Operator's manual

2.2 DC VOLTS

The following specifications apply to the TECH 350 and TECH 360, unless otherwise indicated.

		ACCURACY (1 YEAR, 20°C to 30°C)	
RANGE	RESOLUTION	TECH 350	TECH 360
±200mV	100µV	±(0.1% reading + 1 digit)	±(0.1% reading + 1 digit
±2V	1mV		
±20V	10mV		
±200V	0.1V		
±1500V	1V		

GENERAL
Automatic polarity indication (+ and − indicated)

INPUT IMPEDANCE
22MΩ

NORMAL-MODE REJECTION
Greater than 60dB above 49Hz

COMMON-MODE REJECTION
Greater than 160dB up to 1500Vdc

RESPONSE TIME
Less than one second

OVERVOLTAGE PROTECTION
1500Vdc or peak ac, any range 6kV transients, ten μseconds

2.3 AC VOLTS

The following specifications apply to the TECH 350 and TECH 360, unless otherwise indicated.

EXTENDED FREQUENCY RESPONSE (TECH 360)
Typically, ±3dB at 100kHz

TECH 350		ACCURACY (ONE YEAR, 20° to 30°)		
RANGE	RESOLUTION	45 Hz to 2kHz	2kHz to 5kHz	5kHz to 10 kHz
200mV	100μV	±(0.6% reading +3 digits)	±(1.0% reading +5 digits)	±(2.0% reading +9 digits)
2V	1 mV			
20V	10 mV			
200V	0.1 V			
1000V	1 V			

TECH 360		ACCURACY (ONE YEAR, 20°C to 30°C)				
RANGE	RESOLUTION	45Hz to 2kHz	2kHz to 5kHz	5kHz to 10kHz	10kHz to 20kHz	20kHz to 40kHz
200mV	100μV	±(0.6% reading +3 digits)	±(1.0% reading +4 digits	±(1.5% reading + digits)	±2% reading +7 digits)	±(5% reading +15 (digits) 200mV & 2V only
2V	1mV					
200V	10mV					
	0.1V					
1000V						Not Specified

CREST FACTOR (TECH 360)
Allowable crest factor (peak/rms ratio) varies from 1.0 to 5.0

CONVERSION TECHNIQUE
TECH 350: Average sensing, calibrated to display rms value of sine wave

TECH 360: True rms responding (ac + dc and ac only)

INPUT IMPEDANCE (ALL RANGES)
2.2 megohms, shunted by less than 100pF

RESPONSE TIME
Less than two seconds (on TECH 360, above 10% of fullscale)

OVERVOLTAGE PROTECTIONS
TECH 350: 1000Vrms ac (1500V peak) or 600Vdc (five seconds maximum above 450Vrms on 200mV range)
TECH 360: ac only: 1000Vrms/1500V peak ac or 600Vdc
ac + dc: 1000V maximum dc + ac rms

(Five seconds maximum above 450Vrms on 200mV range)

2.4 DC CURRENT

The following specifications apply to the TECH 350 and TECH 360, unless otherwise indicated.

GENERAL
Automatic polarity indication (+ and − indicated)

RESPONSE TIME
Less than one second

VOLTAGE BURDEN
200μA to 200mA ranges: 300mV maximum at fullscale
2A and 10A ranges: 900mV maximum at fullscale

OVERCURRENT PROTECTION — A INPUT
Two amperes, 250V front panel fuse in series with 3A, 600V internal fuse

OVERCURRENT PROTECTION — 10A INPUT
Up to 20 amperes for fifteen seconds (unfused)

		ACCURACY (ONE YEAR, 20°C to 30°C)	
RANGE	RESOLUTION	TECH 350	TECH 360
±200μA	100nA	±(0.35% reading +1 digit)	±(0.35% reading +1 digit)
±2mA	1μA		
±20mA	10μA		
±200mA	100μA		
±10A*	10mA	±(1.0% reading +1 digit)	±(1.0% reading +1 digit)

*Continuous measurements up to 10 amperes, fifteen seconds maximum from 10 to 19.99 amperes.

2.5 AC CURRENT

The following specifications apply to the TECH 350 and TECH 360, unless otherwise indicated.

		ACCURACY (ONE YEAR, 20 C to 30 C)					
		45Hz to 400Hz		400Hz to 2kHz		2kHz to 5kHz	
RANGE	RESOLUTION	TECH 350	TECH 360	TECH 350	TECH 360	TECH 350	TECH 360
200µA 2mA 20mA 200mA 2A	100mA 1µA 10µA 100µA 1mA	±(0.5% reading +3 digits)		±(0.9% reading +3 digits)	±(0.9% reading +3 digits)	Not Specified N/A	±1.5% reading +3 digits) N/A
10A	10mA	±(1.5% reading +3 digits)		N/A	N/A	N/A	N/A

CREST FACTOR (TECH 360)
1:1 to 5:1, refer to figure on page 21.

CONVERSION TECHNIQUE
TECH 350: Average sensing, calibrated to display rms value of sine wave
TECH 360: True rms responding (ac + dc)
Less than two seconds above 10% of fullscale

VOLTAGE BURDEN
200µA to 200mA ranges: 300mV maximum at fullscale
2A and 10A ranges: 900mV maximum at fullscale.

OVERCURRENT PROTECTION — A INPUT
2 amperes, 250V front panel fuse in series with 3A, 600V internal fuse

OVERCURRENT PROTECTION — 10A INPUT
Up to 20 amperes for fifteen seconds (unfused)

2.6 RESISTANCE

The following specifications apply to the TECH 350 and TECH 360, unless otherwise indicated.

GENERAL
Low-power ohms on all ranges, except 20Ω range.

RANGE	RESOLUTION	MAX TEST CURRENT	ACCURACY (20°C to 30°C) TECH 350	TECH 360
20Ω	01	4mA	0.75% reading + 1 digit	0.5% reading + 1 digit
200Ω	0.1Ω	2.5mA		
2kΩ	1Ω	250μA	±(0.2% reading + 1 digit)	±(0.2% reading + 1 digit)
200kΩ	100Ω	2.5μA		
2MΩ	1000Ω	250nA		
20MΩ	10kΩ	25nA	±(1.0% reading + 1 digit	±(1.0% reading + 1 digit

MAXIMUM OPEN-CIRCUIT VOLTAGE
0.5V, all ranges except 7V on 20Ω range

MAXIMUM IN-RANGE VOLTAGE (Low-Power Ohms)
250mV, all ranges

RESPONSE TIME
Less than one second, except on 20MΩ range, less than four seconds

OVERLOAD PROTECTION
440Vdc or rms ac, any range

2.7 DIODE TEST

The following specifications apply to the TECH 350 and TECH 360, unless otherwise indicated.

RANGE
0V to 1V

RESOLUTION
1mV

ACCURACY
TECH 350: ±(0.1% reading + 2 digits)
TECH 360: ±(0.1% reading + 2 digits)

ACCURACY CONDITIONS
One year, 20°C to 30°C

TEST CURRENT
4mA, ±10%

RESPONSE TIME
Less than one second

OVERLOAD PROTECTION
440Vdc or rms ac

2.8 INSTA-OHMS QUICK CONTINUITY INDICATOR

RESPONSE TIME
Less than one second

2.9 TEMPERATURE

The following specifications apply to the TECH 360 only.

INPUT JACK
Accepts industry standard miniature and subminiature K-type thermocouple connector.

SENSING RANGE
−20°C to 1265°C

RESOLUTION
1°C

ACCURACY (at 25°C ambient)

TEMPERATURE RANGE (°C)	INSTRUMENT ACCURACY
−20 to 0	±(1.2°C + 1 digit)
0 to +70	±(0.5°C + 1 digit)
+70 to +100	±(1.2°C + 1 digit)
+100 to +300	±(1.5°C + 1 digit)
+300 to +1265	±(2.5% reading + 1 digit)

NOTE
Accuracy includes zero and calibration errors and NBS conformity, but does not include thermocouple error.

CORRECTION
NBS K-type thermocouple table. Corrected to 1971 NBS Thermocouple table for ANSI K-type thermocouple junction

COLD JUNCTION CORRECTION
±1°C 0°C to 50°C ambient

SECTION THREE PREPARATION FOR USE

This section contains paragraphs that describe the following: unpacking and inspection; installation; controls, indicators, and connectors; and initial checkout procedure.

3.1 UNPACKING AND INSPECTION

Remove the multimeter from the shipping container. The box should contain the following items:

1. Multimeter
2. Test lead set (one black, one red)
3. Operator's manual for the TECH 350 and TECH 360.
4. 6 heavy-duty D size batteries (installed)
5. Three fuses (two installed and one spare inside the case). To gain access to inside of instrument, see Paragraph 6.2.3.

Account for and inspect all of the above items. If any of the items are damaged or are missing, *immediately return the complete package to the place of purchase for an exchange.*

NOTE

Retain the shipping container for use if instrument must be returned for exchange or repair.

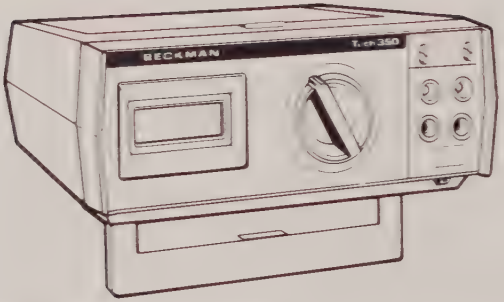
3.2 INSTALLATION

The Multimeter is shipped ready for use. The only action required by the user is to place the tilt bail in the desired position. Figure 1 shows the various positions of the tilt bail.

3.3 INSTRUMENT FAMILIARIZATION

This paragraph is designed to familiarize the user with the controls, indicators, connectors, and other features of the Multimeter. It is HIGHLY RECOMMENDED that the user become familiar with the controls, indicators, and connectors shown and described in Figure 2 before operating the device.

1. Digital Display
   A 3½ digit LCD readout (maximum reading 1999) with automatic decimal point placement, automatic polarity indication, overrange indication, low battery indication (blinking decimal point), and the Insta-Ohms Quick Continuity Indicator(Ω). Indicates measured input value in volts, amperes, or ohms as selected by the Function/Range Switch.
2. Power Switch
   The power switch is located in the extreme upper right-hand corner of the unit. The two-position switch must be in the ON (1) position to turn the meter on. To turn the meter off (O) move the switch downward toward the word OFF.
3. Function/Range Switch
   This control on the Multimeter greatly simplifies the operation of the instrument. The one switch selects the function, and selects the desired range. Seven functions can be selected by directing the pointer on the center bar to: DCV, ACV, DCA, ACA, Ω (ohms), °C (rms 3060) or Diode Test (⏚). The DVC function provides five ranges from 200mV to 1500 volts dc. The ACV function provides five ranges from 200mV to 1000 volts rms ac. The DCA and ACA functions each provide six ranges of current measurements from 200μA to 10A fullscale. The (Ω) function provides seven ranges of resistance measurements from 20Ω to 20MΩ. The continuity test function operates in any resistance range.
4. Low Resistance Measurements
   For measuring resistance between 0Ω to 20Ω, the knob indicator should be switched to the 20Ω range. Make firm contact between the test lead probe tips and adjust the zero control knob to 0. The knob is located just below the front panel. Resistance of the test leads has now been compensated.
5. Diode Test Function
   Diode test position is used for checking diodes and other semiconductor junctions.
6. 10A Input Connector
   Banana jack connector used for continuous current measurements from 0A to 10A. Measurements between 10 amperes and 20 amperes for a duration of fifteen seconds maximum may also be made using this terminal. Inputs beyond this maximum may cause damage to the instrument.



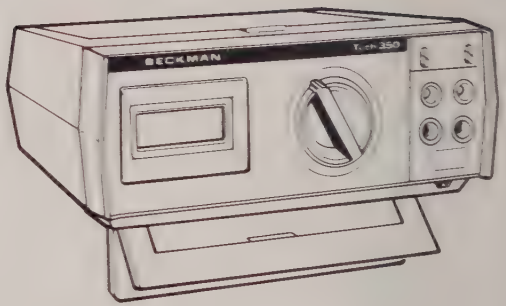


Figure 1. Positioning the Tilt Bail

7. A Input Connector
   Banana jack connector used for current measurements up to 2A. The instrument is protected by a fuse against inputs over 2 amperes.
8. COM Input Connector (Black)
   Banana jack connector used as the common or low input for all measurements.
9. V·Ω Input Connector
   Banana jack connector used as the high input for all voltage and resistance measurements.
10. RMS Switch
    For measuring waveforms that are AC coupled (DC component is removed), place the RMS Switch in the AC position. For measuring the complete waveform, place the switch in AC + DC position.

11. Beeper Switch
    To obtain an audible indication of continuity, place the front panel switch with the horn symbol ( ) into the ON position. A continuous beep indicates that continuity has been established. Place this switch in the OFF position to turn off the beeper.
12. Temperature Jack
    The temperature jack is located in the lower right-hand corner of the front panel. To measure a wide range of temperature (−200°C to +1265°C), plug in a K-type thermocouple and take the reading from the digital Display.

3.4 INITIAL CHECKOUT

Before placing the Multimeter into use, a simple checkout procedure will ensure that the device is working properly. The only equipment required is the test leads.

1. Be certain that batteries and fuse are installed properly, see Paragraphs 6.2.2 and 6.2.3.
2. Connect the red test lead to the V·Ω Input Connector and the black test lead to the COM Input Connector.
3. Switch the Power Switch to ON.
4. Place the Function/Range Switch in the 1500 DCV position.

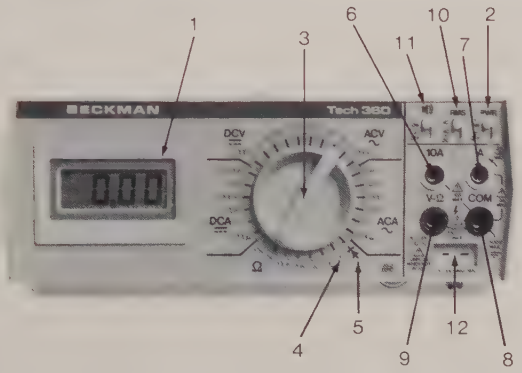


Figure 2. Operating Controls, Indicators and Connectors

5. Touch the red test lead and black test lead together. Observe the Digital Display; it should read 000 ±1.
6. Turn the Function/Range Switch counterclockwise to each DCV position while observing the Digital Display. With the test lead tips in contact, the Digital Display should read zero plus or minus one digit and the decimal point positioned as follows:

1500V	000
200V	00.0
20V	0.00
2V	.000
200mV	00.0

7. Turn the Function/Range Switch to the 20MΩ position. With the two test lead tips separated, the Digital Display should read 0L (overrange).
8. Touch the test lead tips together and observe the Digital Display; it should read 0.00 or 0.01.
9. Turn the Function/Range Switch to each Ω position while observing the Digital Display. With the test lead tips in contact, the Digital Display may read 000.1 or 000.2 because of test lead resistance. The decimal point should be positioned as follows:

20MΩ	0.00
2MΩ	.000
200kΩ	00.0
20kΩ	0.00
200Ω	00.0
20Ω	0.00

10. Turn the Function/Range Switch to the 1000 ACV position.

WARNING

The next step requires the measurement of the local ac line (mains) voltage. Be careful not to touch the test lead tips with fingers and do not allow the tips to contact each other.

11. Measure the load line (mains) voltage at a convenient ac power outlet. The Digital Display should show the appropriate voltage.
12. Remove both probes from the ac outlet.
13. If the instrument has performed properly during this checkout procedure, it is fully operational and ready to use.

This section of the manual describes the various operating modes of the Multimeters as well as a summary of warnings and precautions.

4.1 WARNINGS AND PRECAUTIONS

The following warnings and precautions are mentioned to protect the user from injury and the instrument from damage.

4.1.1. WARNINGS

1. Use extreme caution when working near high voltage sources. This includes any voltage measurements requiring the use of 200Vac, 1000Vac, 200Vdc, and 1500Vdc Ranges.
2. To avoid electrical shock hazard and/or damage to the instrument, do not measure voltages that might exceed 1500 volts above earth ground.
3. Using the A Input Connector during current measurements, operator injury or damage to the instrument may occur if the fuse blows in a circuit which exhibits an open-circuit voltage greater than 600 volts.
4. Before each instrument use, inspect test leads and connectors for cracks or breaks in the insulation. If any defects are found, replace item immediately.
5. To avoid electrical shock hazard, do not touch test leads, tips, or the circuit being tested, while power is applied to the circuit being measured.
6. When making measurements other than temperature, the thermocouple must be disconnected from the meter input. Otherwise, the unit will not operate correctly.

4.1.2 PRECAUTIONS

1. Exceeding the maximum input overload limits can damage the Multimeter.

2. When making current measurements, make sure that the Multimeter is connected in series with the load in which the current is to be measured. NEVER connect the Multimeter ACROSS a voltage source. If this is done, it may either blow the overload protection fuse or damage the device being tested. If the source is capable of delivering in excess of 600V at 10 or more amperes, it may damage the meter.

4.2 OVERLOAD INDICATION

The Multimeters are equipped with automatic overload indication. This means that whenever an input signal is larger than the range selected, an OVERLOAD symbol (OL) will appear in the Digital Display. See Figure 6. This feature allows the user to test devices with unknown circuitry where an overload condition might exist. See Section Five for a complete description of overload protection.

4.3 VOLTAGE MEASUREMENTS

4.3.1 DC VOLTAGE

1. Connect red test lead to V·Ω Input Connector and black test lead to COM Input Connector.
2. Set Function/Range Switch to desired DCV position. If magnitude of voltage is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. Turn off power to device or circuit being tested and discharge all capacitors.

WARNING

To avoid electrical shock hazard and/or damage to the instrument, do not attempt to measure voltages that might exceed 1500 volts.

4. Connect test leads to device or circuit being measured.
5. Turn on power to device or circuit being measured. Voltage value will appear on Digital Display along with the voltage polarity.
6. Turn off power to device or circuit being tested and discharge all capacitors before disconnecting test leads from device or circuit being tested.

4.3.2 AC VOLTAGE

1. Connect red test lead to V·Ω Input Connector and black test lead to COM Input Connector.

2. Set Function/Range Switch to desired ACV position. If magnitude of voltage is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. Turn off power to device or circuit being tested and discharge all capacitors.

WARNING

To avoid electrical shock hazard and/or damage to instrument, do not attempt to measure voltage that might exceed 1000 volts rms or 1500 volts peak ac.

4. Connect test leads to device or circuit being measured.
5. Turn on power to device or circuit being measured. Voltage value will appear on Digital Display.
6. Turn off power to device or circuit being tested and discharge all capacitors before disconnecting test leads from device or circuit being tested.

4.3.3 TRUE RMS MEASUREMENTS (TECH 360)

The TECH 360 permits the direct measurements of the total rms (ac + dc) value of a signal. This is particularly useful in measuring the output of power-control circuits and switching power supplies. Occasionally, however, one may want to know only the ac component, such as in measuring the ripple on a power supply output. This can be easily accomplished by placing the front panel switch from ac + dc to ac only location. Selection of an appropriate ACV range then gives a direct reading of the signals rms ac component.

4.3.4 APPLICATION NOTE

Understanding the ac conversion process in your Multimeter will help you to more fully utilize its measurement capability.

The ac converter used in the TECH 350 is "average-responding." An rms value is determined by first rectifying and filtering the signal to obtain the average value. The average value is then scaled upward by a factor of 1.11 to obtain the rms value. The scaling factor of 1.11 is accurate in the measurement of sine wave signals for which the relationship between the average and rms values is as follows:

$$Vrms = \frac{2\sqrt{2}\ Vavg}{\pi}$$
$$= 1.11\ Vavg$$

In measuring non-sinosoidal waveforms, however, significant errors can be introduced because of different scaling factors relating average to rms values. Rough correction factors can be sometimes calculated for standard waveforms that are free from significant noise and distortion, but accurate measurements of complex waveforms can be difficult to achieve.

RMS values of non-sinusoidal ac signals can be measured directly and more accurately with the TECH 360, which features a "true-rms responding" ac converter. True rms ac response can be particularly useful in measuring complex or noisy signals for which even rough correction factors cannot be easily computed.

Ac converters of all types are limited to their frequency response and input dynamic range. Bandwidth defines the range of frequencies in which the conversion accuracy is within 3dB. The bandwidth of the TECH 360 is 100kHz. Measurements of complex signals will not be affected by converted bandwidth limitations unless there are significant harmonic components beyond 100kHz.

Crest factor is a measure of the input dynamic range of a true-rms responding ac converter. It expresses the capability of the ac converter to handle a signal that has large peak values compared to its rms value without saturating the converter circuitry and degrading the specified accuracy.

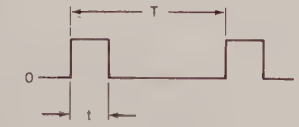
For the TECH 360, crest factor is defined as the ratio of the peak voltage to the total rms (ac + dc) voltage.

$$\text{Crest Factor} = \frac{V\ peak}{Vrms}$$

Crest factor for a pulse train is also related to duty cycle (D) as follows:

$$\text{Crest Factor} = \frac{1}{\sqrt{D}}$$

where $D = \frac{t}{T}$



Crest factor for the RMS ranges from 1.0 to 5.0 on each voltage scale, depending on the rms value of the signal being measured. At fullscale (1999 counts), signals with crest factor between 1.0 and 1.5 can be measured. Signals with crest factor of 1.0 include a square wave or pure dc (peak voltage equals rms voltage). An undistorted sine wave signal (crest factor = 1.414) can also be measured at fullscale. Even a sine wave with considerable harmonic distortion can still be accurately measured at fullscale.

At half scale (1000 counts), signals with crest factor between 1.0 and 3.0 can be measured without performance degradation. At 600 counts and below, signals with crest factors up to 5.0 can be measured. If the crest factor of a waveform is not known, it can be determined by measuring the peak voltage with an oscilloscope and dividing by the rms voltage measured by the Multimeter. The crest factor of some typical waveforms are shown in Figure 3.

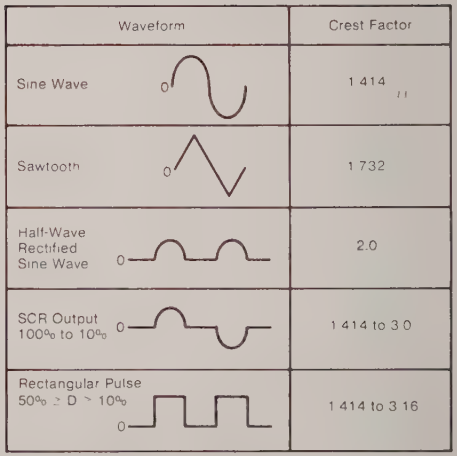


Figure 3. Typical Waveform Crest Factors

4.4 CURRENT MEASUREMENTS

4.4.1 DC CURRENT

1. Connect red test lead to the A Input Connector for current measurements up to 2 amperes. For current measurements between 2 and 10 amperes, connect red test lead to the 10A Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired DCA position. If magnitude of current is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. Turn off power to device or circuit being tested and discharge all capacitors.
4. Open circuit in which current is to be measured. Now securely connect test leads in series with the load in which current is to be measured.
5. Turn on power to circuit being tested.
6. Read current value on Digital Display.
7. Turn off all power to circuit being tested and discharge all capacitors.
8. Disconnect test leads from circuit and reconnect circuit that was being tested.

4.4.2 AC CURRENT

1. Connect red test lead to A Input Connector for measurements up to 2 amperes. For current measurements between 2 and 10 amperes, connect red test lead to 10A Input Connector. Connect black test lead to COM Input Connect.
2. Set Function/Range Switch to desired ACA position. If magnitude of current is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. Turn off power to device or circuit being tested and discharge all capacitors.
4. Open circuit in which current is to be measured. Now securely connect test leads in series with the load in which the current is to be measured.
5. Turn on power to circuit being tested.
6. Read current value on Digital Display.
7. Turn off all power to circuit being tested and discharge all capacitors.
8. Disconnect test leads from circuit and reconnect circuit that was being tested.

Note that the RMS Switch on the TECH 360 front panel is **not** applicable to ac current measurements.

4.5 RESISTANCE MEASUREMENTS

All resistance ranges (except 20Ω range) on the Multimeter are low-power ohms which allow accurate measurements of in-circuit resistance. (Use Diode Test Function for checking diode and other semiconductor functions.)

1. Connect red test lead to V·Ω Input Connector and black test lead to COM Input Connector.
2. Set Function/Range Switch to desired Ω position. If magnitude of resistance is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. If the resistance being measured is connected to a circuit, turn off power to circuit being tested and discharge all capacitors.
4. Connect test leads to circuit being measured. When measuring high resistance, be careful not to contact adjacent points, even if insulated, because some insulators have a relatively low insulation resistance, causing the measured resistance to be lower than the presumed resistance.
5. Read resistance value on Digital Display. If a high resistance value is shunted by a large value of capacitance, allow Digital Display to stabilize.
6. For measuring resistance less than 20Ω, the knob indicator should be set to the 20Ω range. Make firm contact between the test leads and adjust the zero control knob, located just underneath the front panel face, until the display reads 0.00. Resistance of the test leads has now been compensated for.

4.6 DIODE AND TRANSISTOR TEST MEASUREMENTS

The special Diode Test Function allows accurate measurements of forward voltage drops across diodes and transistor junctions. A constant-current source forces 4mA of current into the semi-conductor junction under test, which results in the voltage drop being displayed on the Digital Display. This function also permits measurement of in-circuit semi-conductor junctions with as little as 300Ω in parallel with the transistor or diode. The limited current produced by the instrument in the Diode Test Function minimizes the possibility of damage to low-power semiconductor junctions, a common problem when using many analog meters.

4.6.1 DIODE TESTS

To perform diode test measurements, use the following procedure:

1. Connect red test lead to V·Ω Input Connector and black test lead to COM Input Connector.
2. Set Function/Range Switch to the Diode Test (—►|—) position.
3. If the semiconductor junction being measured is connected to a circuit, turn off power to circuit being tested and discharge all capacitors.
4. Connect test leads to device.
5. Read forward voltage drop on Digital Display. If the Digital Display reads OL, reverse the lead connections. The placement of the leads when the forward voltage is displayed (normally 600mV to 900mV) indicates the orientation of the diode. The red lead is then connected to the anode and the black lead is connected to the cathode as shown in Figure 4.

   If OL is displayed with both lead connections, the junction is open.

   If a low reading (less than 1 volt) is obtained with both lead connections, the junction is shorted internally or (if the junction is measured in a circuit) the junction is shunted by a resistance less than 300 ohms. In the latter case, the junction must be disconnected from the circuit in order to verify its operation.

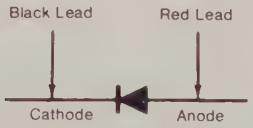


Figure 4. Placement of Leads in Respect to Anode and Cathode

4.6.2 TRANSISTOR JUNCTION TESTS

Transistors can be tested in the same manner as diodes by checking the two diode junction formed between the base and emitter and the base and collector of the transistor. Measurements between the collector and emitter also should be made to determine if a short is present.

4.6.3 TRANSISTOR BETA TEST

With a simple test fixture, the Diode Test Function can be used to determine the dc current gain (beta) of a transistor. Beta is measured using dc collector-to-emitter voltage VCE of about 1 volt and a collector current (IC) of about 4mA.

The transistor Beta test setup is shown in Figure 5 for a NPN transistor. For PNP transistors, the connections to the Multimeter should be reversed. To determine transistor Beta, use the following procedure:

1. With all the connections made as shown in Figure 5, and with switch S1 open, record the displayed reading (ignore decimal point).

NOTE

If an overload indication is obtained, reverse the connections to the Multimeter.

If an overload indication is obtained regardless of meter orientation, or if a reading less than 0.200 is obtained, the transistor is probably defective.

2. Close switch S1 and record the new displayed reading (ignore decimal point).
3. Divide 4000 by the difference in digits between the readings obtained in Steps 1 and 2 immediately preceding. The resulting number is the transistor's dc beta.

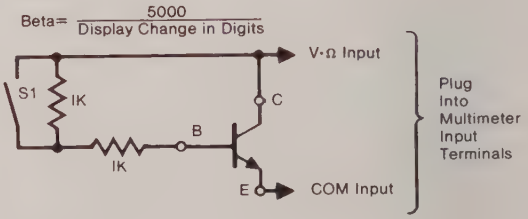


Figure 5. Test Fixture for Transistor Beta Measurement

4.7 CONTINUITY AND CAPACITOR CHECKS

Before the Beckman Digital Multimeter, quick continuity checks using a digital volt/ohm meter were not possible. Now they can be done just as quickly and as easily as with an analog meter. This feature is particularly useful in circuit and cable tracing, but also may be used for troubleshooting small-value capacitors.

4.7.1 CONTINUITY CHECKS

1. Place Function/Range Switch in any Ω range.
2. Connect red test lead to the V·Ω Input Connector and the black test lead to the COM Input Connector. With the test leads separated or measuring an out-of-range resistance, the Digital Display will indicate OL (overload), Figure 6.
3. Place one test lead probe at one end of cable or circuit to be tested. Use the other test lead to trace the circuit or cable until the circuit is complete. When continuity is established, an Ω symbol will appear in the upper lefthand corner of the Digital Display, Figure 7. If an audible tone is desired to check continuity, push the front panel switch with the horn symbol ( ) to ON. A continuous beep will be heard once continuity is established. If contact in the cable or circuit is maintained long enough (about 1/4 of a second), the OL will disappear and the resistance value of the cable or circuit will appear next to the Ω, Figure 8.

NOTE

The Insta-Ohms Quick Continuity Indicator is triggered by any resistance less than double the maximum resistance measureable on the selected range. For example, on the 200Ω range, the Ω symbol will appear when less than 400Ω are detected by the instrument (except on the 20Ω scale).

Figure 6. Display of Overload Symbol

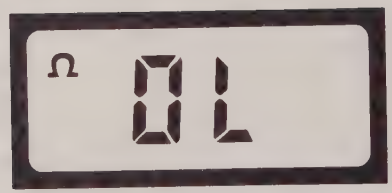


Figure 7. Display of Insta-Ohms Quick Continuity Indicator (Ω)

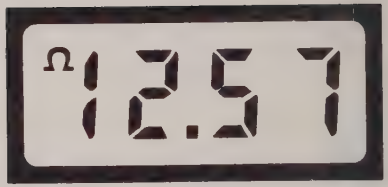


Figure 8. Display of Insta-Ohms Quick Continuity Indicator (Ω)

4.7.2 CAPACITOR CHECKS

The Insta-Ohms Quick Continuity Indicator also can be used as rough check of capacitors with a value greater than or equal to 0.01 μF. This feature can be a great aid in troubleshooting circuits in which an open or shorted bypass capacitors is suspected. Use the following procedure to check capacitors:

1. Place Function/Range Switch in 20MΩ range position.
2. Connect red test lead to V·Ω Input Connector and the black test lead to the COM Input Connector. With the test leads separated the Digital Display will indicate OL (overload), Figure 6.

3. Discharge the capacitor to be checked by briefly shorting the ends together.
4. Place red test lead probe at one end of capacitor. Place the black test lead at other end of capacitor.

NOTE

Do not touch capacitor leads or test probe ends during capacitor check because proper operation of Insta-Ohms feature could be affected.

5. If the Insta-Ohms symbol (Ω) appears briefly and then disappears, the capacitor is accepting a charge. If the Insta-Ohms symbol does not appear, reverse the test leads. If the Insta-Ohms symbol still does not appear, the capacitor is probably open. If the capacitor is shorted, a low resistance value will be displayed.

NOTE

Insta-Ohms can only be used to check capacitors with a value of 0.01 μF or greater.

4.8 DECIBEL MEASUREMENTS

In addition to its normal functions, the Multimeter can be used to measure decibels. The value obtained from this measurement can be used to indicate the gain and accuracy of electronic devices. The decibel (dB) is the logarithm of the ratio of two electrical signals; usually a certain amount of power across a fixed resistance is used as a reference and denoted as 0 (zero) decibels. In our example, 0 dB is defined as 1 milliwatt into 600 ohms. Use the procedure of Paragraph 4.3.2 to determine ac voltage and the graph of Figure 9 to determine decibel value.

4.9 TEMPERATURE MEASUREMENTS

Place Function/Range Switch in C position. Plug a standard K-type thermocouple into the thermocouple jack at the lower right-hand corner of the front panel. The appropriate temperature will appear on the Digital Display.

NOTE

Thermocouple **must** *be removed for normal multimeter measurements!*

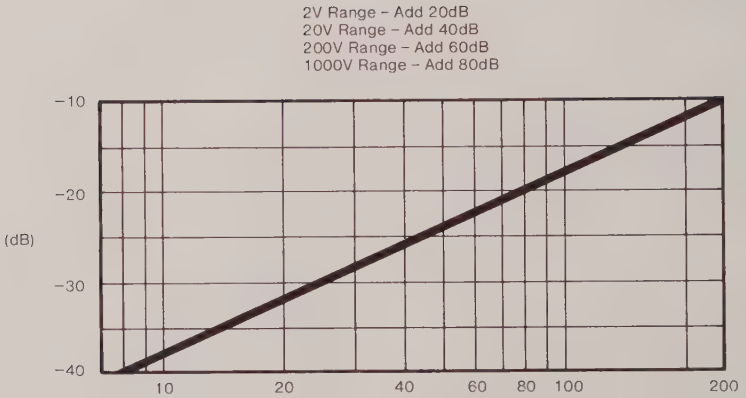


Figure 9. Decibel Conversion Chart

5.1 GENERAL

The central part of the Beckman Digital Multimeter is the custom-designed CMOS LSI multiprocessor chip, U7. Please note in the following test that where the TECH 360 has a particular identification for an electronic component, the term will appear in parenthesis, i.e., (U3). To increase instrument reliability, much of the necessary electronic circuitry is incorporated on the multiprocessor chip. The chip contains an active input filter, an averaging ac-to-dc converter, the Insta-Ohms detection and resistance measurement circuitry, an analog-to-digital converter with ±200mVdc fullscale ratiometric inputs, and all necessary digital and LCD display drive circuitry.

Peripheral components are used with this chip to perform a range of voltage, current, resistance, and semiconductor measurements, and to provide overall instrument protection.

Included in these peripheral circuits are the Function/Range Switch, 3 resistor networks, a voltage reference diode, several circuit protection components, the battery, and the display. The TECH 360 also contains an additional LSI chip which performs true rms conversion of the ac signals.

5.2 OVERALL FUNCTIONAL DESCRIPTION

Simplified block diagrams are shown in Figure 10 and Figure 11. Schematic wiring diagrams are shown in Figure 12 and Figure 13.

The Function/Range Switch routes the input signal to an appropriate input Conditioning Circuit which converts the input signal to a dc voltage between −200mV and +200mV.

This signal can then be processed by the multiprocessor chip. After being passed through an active filter for normal-mode rejection of interfering powerline and audio frequency signals, the on-chip A/D converter digitizes the signal into display segment driving signals, resulting in an accurate digital display for the applied input signal.

Decimal point positions on the display are determined automatically by the multiprocessor chip, based upon the Function/Range Switch settings.

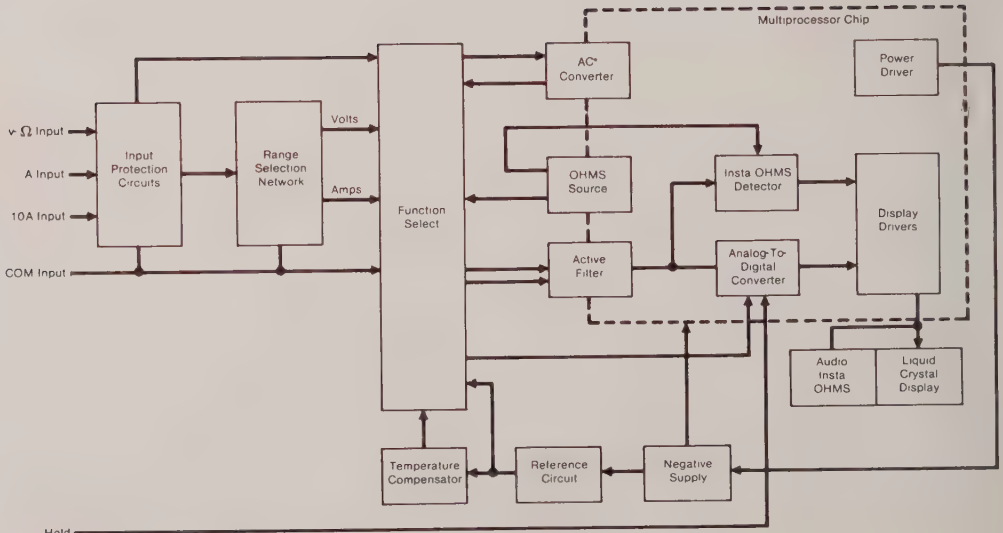


Figure 10. Simplified Block Diagram TECH 350.

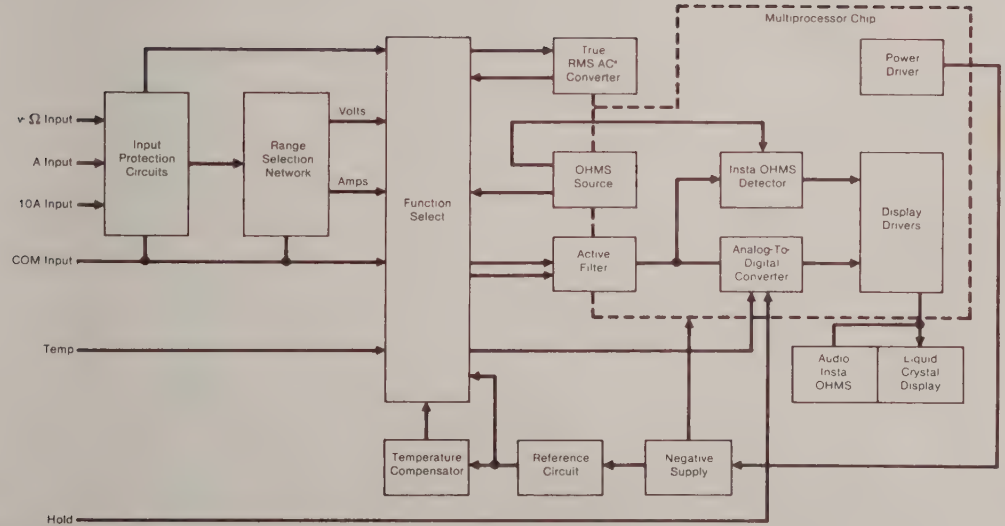


Figure 11. Simplified Block Diagram TECH 360

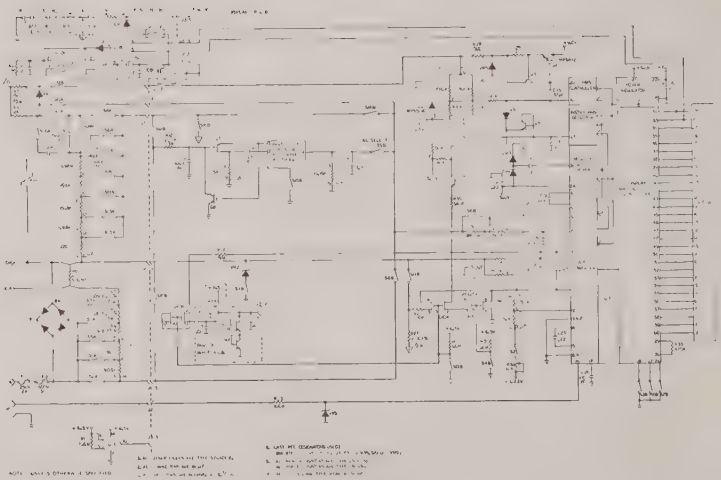


Figure 12. Schematic Wiring Diagram of Model TECH 350

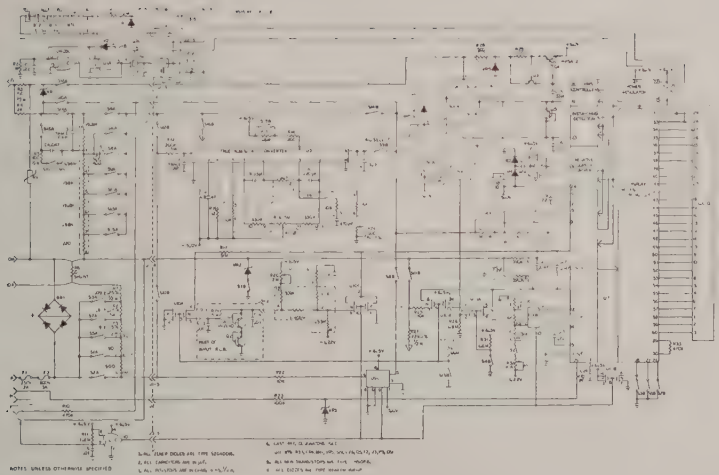


Figure 13. Schematic Wiring Diagram of TECH 360

5.3 BLOCK DIAGRAM ANALYSIS

5.3.1 INPUT PROTECTION CIRCUITRY

Input protection circuitry has been provided to protect the instrument from normally encountered overloads and range selection errors.

In the dc voltage ranges, primary over voltage protection is provided by a 2MΩ series resistor R30 working into voltage limiters included in the converter chip. Continuous overloads of 1500Vdc and energy-limited transients of much higher voltage can be accepted. Secondary protection from high transient voltages is provided by a 150 ohm, 2k ohm, metal-oxide-resistor (mov) circuit. On all resistance ranges and the diode test function, a positive temperature coefficient resistor R28 and zener diodes VR2, VR5, provide isolation from the application of external voltages.

In the current mode, protection is provided by a combination of a diode limiter bridge BR1, a 2-ampere 250-volt fuse F1, and a 600V/3A fuse F2. The 2A/250V fuse will blow for long-term overloads and the diodes divert overloads from the current measurement resistors. The 600V/3A fuse will blow when voltages are high enough to arc across the 2A/250V fuse. The 600V/3A fuse is for operator protection only; meter damage may occur.

Although not fuse-protected, the 10A current input connects directly into a durable 10MΩ current shunt R1 that can withstand 10 amperes continuously (and up to 20 amperes for a short duration less than fifteen seconds).

5.3.2 INPUT CONDITIONING CIRCUITS

The A/D converter on the multiprocessor chip accurately converts an unknown voltage within the range of −200mV to +200mVdc to a digital equivalent which is displayed on the Digital Display. If the signal being measured is other than a dc voltage in the ±0.2V range, the signal must be converted to a dc voltage and scaled down before being presented to the A/D converter. This is the function of the input conditioning circuits.

Voltage Measurements

A precision-ratio resistor network is used as the voltage divider for both ac and dc voltage ranges. The voltage divider is part of a Beckman thin-film resistor network U1. Thin-film resistor networks exhibit exceptionally good long-term stability and contribute significantly to the long-term accuracy of Beckman Multimeters.

If the ±200 mVdc range is selected, the input signal feeds directly into the multiprocessor chip. On all other higher dc voltage ranges, a precise power-of-ten voltage is selected from the voltage divider as the multiprocessor input. If an ACV range is selected, a voltage divider output is coupled to an ac converter which in turn provides a proportional output to the active filter input to the multiprocessor chip.

On the TECH 350, the ac converter is an *averaging* converter, a precision half-wave rectifier whose output is a dc voltage calibrated to equal the rms value of a sine wave input. The ac converter is located on the multiprocessor chip and is separately powered to save battery drain except during ac voltage and ac current measurements.

On the Model TECH 360, the ac conversion process is accomplished in the true rms converter chip (U3). The TECH 360 calculates the rms value of an input voltage by performing the electronic equivalent of the actual mathematical function:

$$Vrms = \sqrt{\frac{1}{T}\int_{0}^{T} V_{IN}^{2}(t)dt}$$

A block diagram of the true rms converter chip is shown in Figure 14.

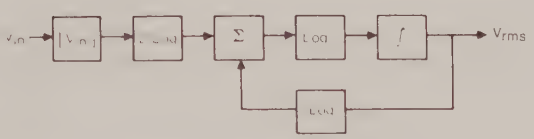


Figure 14. True rms Converter Block Diagram

Resistance Measurements

Resistance measurements are made using a ratio technique when the unknown resistance is compared against an internal standard. As shown in Figure 15, the unknown resistance is connected in series with a selected reference resistor to a bias voltage generated by the multiprocessor chip.

The reference resistor is selected to be equal to the fullscale range of the unknown resistor being measured, e.g., if the 20KΩ range is selected, a precision 20KΩ resistor is switched across the reference input. Reference resistors are selected from the same thin-film resistor network (U1) used as the voltage divider for voltage measurements. Because of negligible loading at the sensing terminals by the multiprocessor chip, the ratio of the two resistors is equal to the ratio of their respective voltage drops.

$$\frac{V_x}{R_x} = \frac{V_{ref}}{R_{ref}}$$

The A/D converter on the multiprocessor chip uses a ratiometric conversion technique which relies solely on the ratio of the unknown voltage, V_x, to a reference voltage, V_{ref}. Choosing a low bias voltage assures that the voltage developed across the unknown resistance is 0.25 volt maximum. This allows low voltage testing of resistors in circuits where the presence of semiconductor junctions could otherwise affect the measurement accuracy.

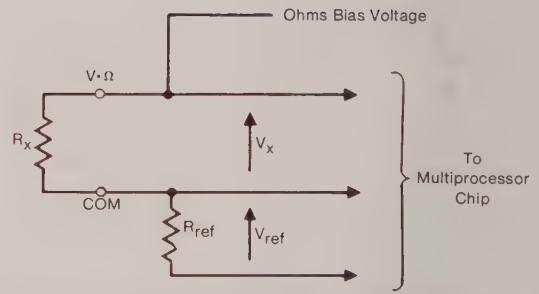


Figure 15. Input Conditioning Circuit for Resistance Measurements.

Current Measurements
Current is converted to a dc voltage by passing the current through a selected shunt resistor, resulting in a voltage drop (I•R) within the ±200mV range required by the multiprocessor chip. This process assures that the maximum voltage burden or voltage dropped through the current sense resistor is less than 0.9V on 2A and 10A ranges, and less than 0.3V on all others.

The resistors that are switched in series to make current shunt values from 0.01Ω to 1kΩ are part of the thin-film network U2 and wirewound resistors R5, R7, R8 and R9.

The voltage drop from a dc current measurement is routed directly to the multiprocessor chip. In ac current ranges, the shunt voltage drop is routed to the same ac converter used in the conversion of ac voltages.

Diode Measurements
The diode test operating mode provides a repeatable and easily understandable means to check semiconductor junctions. In this mode, the Multimeter operates with a ±1 volt fullscale dc measurement range. A 4mA constant test current is supplied via the V·Ω terminal. The resulting junction forward voltage drop is scaled to within ±200mV by the voltage divider, converted in the multiprocessor chip, and displayed. Reverse connection (checking diode blocking) will normally read 0L.

5.3.3 MULTIPROCESSOR CHIP

The multiprocessor chip contains the averaging ac converter, an active input filter, the Insta-Ohms detector, the A/D converter, circuits for controlling the voltage polarity signs, the overload indicator and the low battery indicator, and all display drivers.

Active Filter
A second-order Bessel filter is incorporated in the multiprocessor chip to insure broadband normal-mode rejection of interfering powerline and audio frequencies. This, combined with the usual 6dB per octave rejection of the integrating converter, provides more than 60dB rejection at powerline frequencies.

Insta-Ohms Quick Continuity Indicator
The Insta-Ohms Quick Continuity Indicator allows a very quick determination of circuit continuity. The Insta-Ohms detector consists of a single-bit analog-to-digital converter that triggers at approximately twice fullscale input in any

ohms range. Because it is separate from the main analog-to-digital conversion circuitry, normal conversion time is not required and indication in the Digital Display occurs almost immediately (within 0.1 second).

A/D Converter

The A/D converter performs a true ratio voltage conversion between two input ports. One input to the A/D converter is the unknown input voltage. For all voltage and current measurements, the reference or second port is connected to a precision voltage reference generated by a band-gap diode VR4 and a voltage divider network U5. The reference voltage is set by an adjustment of trimmer R32. In the TECH 350, this one trimmer comprises the only adjustment required for calibration.

When the unknown input voltage exactly equals the reference voltage, a fullscale reading results from the A/D converter. As the ratio of the unknown input voltage to the reference voltage declines, proportionally lower readings result from the main converter.

In the resistance ranges, the reference input is supplied by the voltage drop across a reference resistor connected in series with the unknown resistance.

This section of the manual describes maintenance procedures, calibration, and troubleshooting. In addition, a general statement on service policy is included. Any questions regarding warranty repair or instrument servicing should be directed to Beckman Instruments, Inc., at (714) 993-8852.

6.1 WARRANTY STATEMENT

The warranty statement for the Beckman Multimeters appears on the inside front cover of this manual. Read it carefully before requesting warranty repairs.

6.1.1 WARRANTY REPLACEMENT

Any Series 300 instrument claimed to be defective should be returned to Beckman Instruments, Inc. with a $3.00 handling fee within the continental USA and $12.00 elsewhere.* Follow the shipping instructions of Paragraph 6.1.3.

Warranty replacement will be made typically within two working days after receipt of defective unit.

6.1.2 NON-WARRANTY REPLACEMENT

Any out-of-warranty instrument that is defective, but repairable, can be exchanged for a reconditioned instrument at a flat rate contained on Beckman's current price list. The replacement unit carries a three (3) month warranty. Contact any authorized Beckman distributor or Beckman Instruments, Inc. for the current non-warranty replacement rates.

6.1.3 SHIPPING INSTRUCTIONS

Instruments returned for calibration or repair should be shipped with the following information or items: company name, customer's name, address, telephone number, proof of purchase (warranty repairs), a description of the problem encountered or service required, and the appropriate service charge.

Service charges should be remitted in either the form of a check, money order, or purchase order made payable to Beckman Instruments, Inc.

*Prices subject to change without notice.

Instruments should be shipped with transportation charges prepaid to the following address:

Beckman Instruments, Inc.
210 S. Ranger Street
Brea, CA 92621
Attn: Customer Service

Instruments will be returned to the customer by UPS or equivalent, with transportation charges paid by Beckman Instruments, Inc.

6.2 MAINTENANCE PROCEDURES

Regular operator maintenance of the Multimeters consists of: cleaning case and window, battery replacement, and fuse replacement. All other repairs should be performed by the Beckman Service Center or other qualified instrument service personnel.

6.2.1 CLEANING CASE AND WINDOW

CAUTION

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These chemicals will react with plastics used in construction of case.

The front panel case should be cleaned with a mild solution of detergent and water. Apply sparingly with a soft cloth and allow to dry completely before using.

6.2.2 BATTERY REPLACEMENT

WARNING

To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before removing top rear housing.

1. After disconnecting test leads and turning off Multimeter, open accessory compartment lid and remove three screws exposed by opening the lid. After screw removal lift up on the top rear housing and remove. Replace batteries. (See Figure 16).

CAUTION

Failure to turn off the instrument before installing the battery could result in damage to the battery if it is connected to the battery terminal incorrectly.

2. Six D-size (1.5V) batteries are located in the rear bottom housing. Install batteries as indicated by figures located on inside rear bottom housing.

WARNING

Do not operate Multimeter with top rear housing removed (except during calibration).

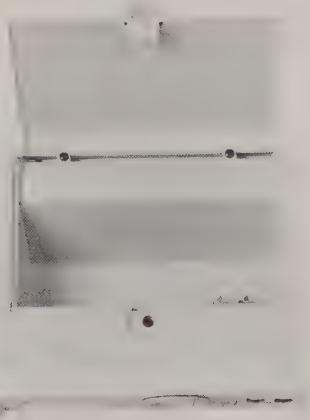


Figure 16. Top View of Multimeter

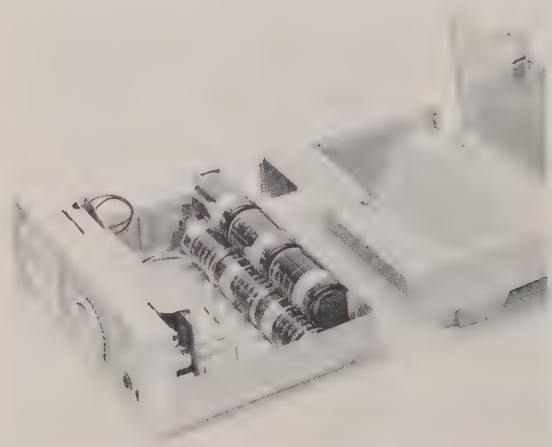


Figure 17. Multimeter with Top Rear Housing Removed

6.2.3 FUSE REPLACEMENT

WARNING

To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before replacing fuse.

1. The fuse is located inside the A input terminal. Turn A insert counterclockwise and remove insert and 2A/250V fuse.
2. Replace fuse and install insert into front panel with clockwise turn.

WARNING

To prevent fire, use Type AGX 2A/250V fuse only.

6.3 CALIBRATION*

In order to maintain the specification described in Section Two of this manual, it is recommended that the Multimeter be calibrated once each year and/or after it is repaired.

Equipment required for calibration is listed in Figure 18.

6.3.1 CALIBRATION OF TECH 350

1. Perform calibration at an ambient temperature of 25 ±2°C and a relative humidity of 80% or less. Allow instrument to stabilize at this temperature for at least thirty minutes.
2. Remove the top rear housing from the instrument by opening the accessory lid and removing three exposed screws and then lifting off top rear housing.
3. Set the output of the dc calibrator for 190mV ±0.02% and connect it to the V·Ω and COM Input Connectors.

*If the necessary equipment is not available, calibration service is available from the Beckman Service Center for $15.00 in the Continental U.S.A. and $25.00 elsewhere. (Prices are subject to change without notice.) Instrument calibration performed at Beckman is traceable to the National Bureau of Standards (NBS). For this service, send the unit and appropriate service charge following the shipping instructions of Paragraph 6.1.3.

Instrument Type	Required Characteristics	Recommended Models
dc calibrator	Voltage Range: 0 to 1000Vdc Accuracy ±0.025%	Rotek 600 or Equivalent
ac calibrator (For use with TECH 360 only)	Voltage Range: 0 to 110Vac Frequency Range: 400Hz to 20kHz Voltage Accuracy: 0.05% at 400Hz; 0.5% at 20kHz	Rotek 600, HP 745A, or equivalent
Thermocouple or Shorting Plug	K-type (chromel-alumel) or Solid copper or aluminum shorting plug	Omega connector SMP-K-M with chromel-alumel wire or equivalent or Omega connector-SMP-U-M with connector terminals shorted with copper wire or equivalent.
Thermometer	0.1°C resolution 0.1°C accuracy	

Figure 18. Equipment Required for Calibration

4. Turn the Function/Range Switch on the Multimeter to the 200mV DCV position.
5. Using a small flat-tipped screwdriver, adjust potentiometer R32 as identified in Figure 19, until Multimeter Digital Display reads + 190.0.
6. Disconnect dc calibrator from Multimeter.
7. Replace rear housing and secure with three screws.

6.3.2 CALIBRATION OF TECH 360

1. Use the procedure of Paragraph 6.3.1 through Step 6, and then proceed as follows.
2. Short the input terminals.
3. Turn Function/Range Switch on Multimeter to the 1000V ACV position.
4. Adjust potentiometer R16, as identified in Figure 20, until the digital Display reads 000 or 001. Make this adjustment *very slowly* to allow the instrument to stabilize.
5. Turn Function/Range Switch on Multimeter to the 200mV ACV position. Place AC/DC Switch in AC + DC position.
6. Set the output of the dc calibrator to 190mV. Connect the dc calibrator to the V·Ω and COM (polarity is not important) Input Connectors.
7. Adjust potentiometer R24, as identified in Figure 20, until the Digital Display reads 190.0 ±1 digit.
8. Disconnect dc calibrator.
9. Place Function/Range Switch on Multimeter in the 2V ACV position and set the ac calibrator for an output of 1.900V, 20kHz.
10. Adjust trimming capacitor C5, as identified in Figure 20, until the Digital Display reads a number equal to 1.900 ±0.001.
11. Replace Multimeter top rear housing and secure with the three screws.
12. Verify that the Digital Display reads 1.900 ±20 digits.
13. Disconnect ac calibrator.
14. Turn Function/Range Switch to °C position. Either of the two approaches may be used: thermocouple or shorting plug. If thermocouple is used, meter is calibrated *only* for the particular thermocouple used and some error may be involved when another thermocouple is used. Shorting plug calibration involves instrument only.

NOTE

Reference thermometer and the meter under calibration should be calibrated in the same environment.

a. Shorting Plug
   1. Remove all connections to meter.
   2. Install shorting plug described in Figure 18.
   3. Adjust R20 for reference thermometer reading ±1°C.
   4. Remove shorting plug.

b. Thermocouple
   1. Remove all connections to meter.
   2. Install K-type thermocouple into K-type TC jack
   3. Place thermocouple end into bath solution, (allow time to stabilize).
   5. Remove thermocouple.

6.4 TROUBLESHOOTING

Except for the replacement of the batteries and the 2A/250V fuse, repair of the Multimeter should be performed only by the Beckman Service Center or by other qualified instrument service personnel.

CAUTION

The CMOS multiprocessor chip U7 is subject to damage created by electrostatic discharge. This component should be handled only by qualified personnel equipped with anti-static grounding devices.

If the instrument is not performing properly, the following steps should be taken before returning the instrument for warranty repair.

1. Check the battery and fuse connections.
2. Check to see that the Function/Range Switch is in the correct position for the type of parameter and range of values being measured, and that the measurement value is within the capability of the instrument.

NOTE

The thermocouple must be removed to make any measurement other than temperature. Otherwise the meter will not operate correctly.

3. Review and comply with the operating instructions contained in Section Four of this instruction manual.
4. Inspect the test leads for breaks or cracks and ensure that the test leads are inserted fully into the input connectors.
5. Check to see that the ambient environment in which the instrument is being used is within the specifications of the instrument.
6. If the decimal point is blinking, the battery is probably low. Replace battery, using procedure for Paragraph 6.2.2.
7. If the Digital Display is blank with the unit turned on, the battery is probably dead. Replace battery, using procedure of Paragraph 6.2.2.
8. If operation is normal in all functions and ranges except ac and dc current, the fuse is probably blown. Replace 2A/250V fuse, using procedure of Paragraph 6.2.3.

If the preceding steps do not remedy the problem, refer to Paragraph 6.1, Warranty and Non-Warranty repair service.

6.4.1 SERVICE MANUAL

A complete service manual is available from Beckman Instruments, Inc., for those users who desire to service their own instruments. To obtain a copy of this manual, send $14.00* (postage and handling) in the form of a check, money order, or a purchase order made payable to Beckman Instruments, Inc. See shipping address in Paragraph 6.1.3.

6.5 INSTRUMENT STORAGE

WARNING

If Multimeter is to be stored at temperatures above 122°F (50°C), remove battery.

*Prices are subject to change without notice.

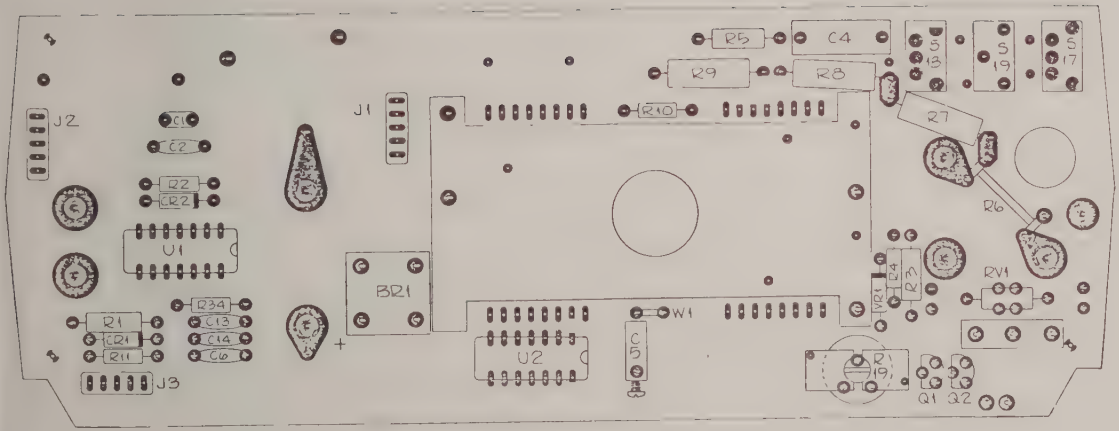


Figure 19. Components Locator for TECH 350 (cont. on Page 50)

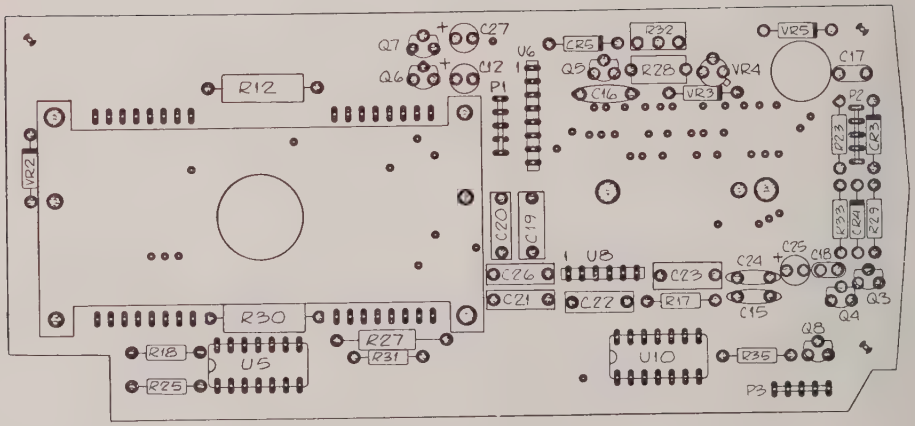


Figure 19. Components Locator for TECH 350

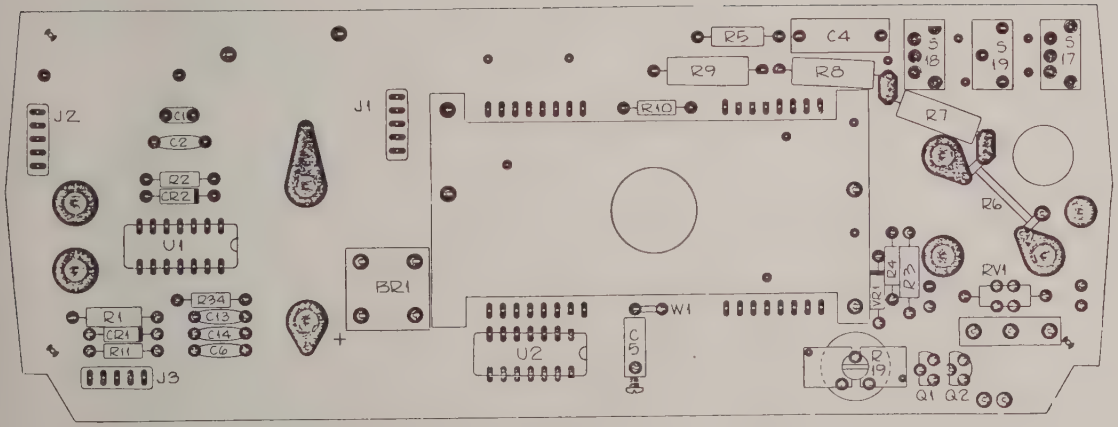


Figure 20. Components Locator for TECH 360 (cont. on Page 52)

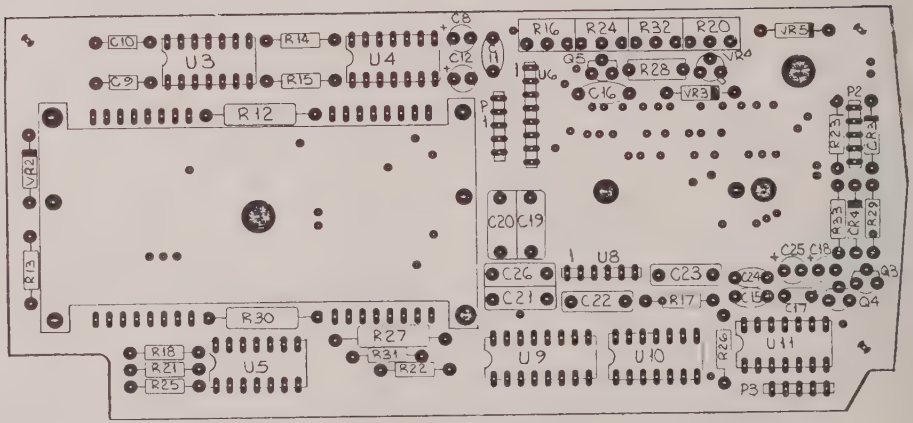


Figure 20. Components Locator for TECH 360

This section provides a description of the accessories that are available from Beckman.

7.1 VINYL CARRYING CASE (DC-206)

The vinyl carrying case is constructed of durable, padded vinyl and will accommodate any Beckman Bench Multimeter model. The case has room for the meter, instruction manual, and the test leads without adding any unnecessary bulk.

7.2 THERMOCOUPLE PROBE (TP-254) AND WIRE (TP-255)

The Temperature probe is a compensated K-type, nickel-chromium/nickel-aluminum hand-held probe and wire thermocouple.

7.3 HIGH-VOLTAGE PROBE (HV-2111)

The High-Voltage Probe extends the dc voltage measurement capability of any Beckman Multimeter to 50kV. This accessory is essential for television and CRT terminal service where second anode voltages must be measured. This probe contains a precision 1000:1 resistor divider that scales high voltages down to a level that the Multimeter can handle safely. The high input impedance of the probe minimizes circuit loading and assures accurate measurements.

7.3.1 HIGH-VOLTAGE PROBE SPECIFICATIONS

VOLTAGE RANGE
0 to ±50kVdc

INPUT RESISTANCE
1000MΩ

DIVISION RATIO
1000 to 1

ACCURACY
±2% at 25kV, changes linearly to 8% at 50kV

MAXIMUM INPUT
±50kVdc or peak ac

7.3.2 OPERATION WITH HIGH-VOLTAGE PROBE

DANGER

The High-Voltage Probe is used to measure potentially lethal voltages. Always disconnect power and discharge voltage source before connecting or disconnecting the High-Voltage Probe.

When the High-Voltage Probe is used, the probe replaces the standard test leads. The probe is connected to the Multimeter in the same manner as the standard test leads and measurements are made as described in Paragraph 4.3.1 except that, because the probe is a precision 1000:1 divider, the Digital Display readings will be in kilovolts. A measured value of 50 000 volts will therefore read +50.0 with the Function/Range Switch in the 200 DCV position.

7.4 RF PROBE (RF-221)

This peak detecting RF Probe extends the ac voltage measuring capability of any Beckman Multimeter to 200MHz. The RF Probe provides a dc voltage that is calibrated to equal the rms value of a sine wave.

7.4.1 RF PROBE SPECIFICATIONS

FREQUENCY RANGE
2KHz to 200MHz
ACCURACY
±(1% input + 50mV), from 2kHz to 10MHz
±1db from 10MHz to 100MHz
±6db from 100MHz to 200MHz
MAXIMUM READING
25Vrms
RESPONSE
Peak sensing, rms calibrated
INPUT IMPEDANCE
1.5MΩ in parallel with 7pF
OVER VOLTAGE PROTECTION
130Vrms at 60Hz or 250Vdc

7.4.2 OPERATION WITH RF PROBE

The RF Probe is connected to the Multimeter in the same manner as the standard test leads. Measurements are made as described in Paragraph 4.3.1. Use appropriate DCV range from 200mV to 200V and read voltage signal directly in volts rms.

7.5 AC CURRENT CLAMP (CT-231)

This accessory extends the ac current measurement capability of any Beckman Multimeter to 150 amperes without breaking the circuit under test. The 1000:1 current transformation allows direct reading in amperes when used with the 200mA ac current range of the Multimeter.

7.5.1 AC CURRENT CLAMP SPECIFICATIONS

RANGE
10 to 150A rms ac
FREQUENCY RANGE
30Hz to 1kHz
ACCURACY
±2% (60Hz)
±3% (50Hz to 1kHz)
DIVISION RATIO
1000:1
CIRCUIT-TO-GROUND VOLTAGE
1000 Vrms maximum
MAXIMUM CONDUCTOR SIZE
0.45 inch (11.4mm)

7.5.2 OPERATION WITH 150A AC CURRENT CLAMP

The CT-231 AC Current Clamp is connected to the A and COM Input Connectors of the Multimeter in place of the standard test leads. The jaws of the current clamp are placed around one of the current carrying conductors. With the Multimeter in the 200mA ACI position, current is read directly in amperes.

7.6 AC CURRENT CLAMP (CT-232)

This accessory extends the ac current measurement capability of any Beckman Multimeter to 1000 amperes by use of a 1000:1 current transformer. The clamp-on design permits ac current measurements without breaking the circuit under test.

7.6.1 AC CURRENT CLAMP SPECIFICATIONS

RANGE
10 to 1000A rms ac
FREQUENCY RANGE
20Hz to 1000Hz
ACCURACY
±1% (60Hz)
±2%% (30Hz to 1kHz)
DIVISION RATIO
1000:1
CIRCUIT-TO-GROUND VOLTAGE
1000V rms maximum
MAXIMUM CONDUCTOR SIZE
2.125 inches (54mm)

7.6.2 OPERATION WITH 1000A AC CURRENT CLAMP

The CT-232 AC Current Clamp is connected to the A and COM Input Connectors of the Multimeter in place of the standard test leads. The jaws of the current clamp are placed around one of the current carrying conductors. With the Multimeter in the 2A ACI position, the displayed value is multiplied by 1000 to get measured current in amperes.

7.7 DELUXE TEST LEAD ACCESSORY KIT (DL-243)

The specially designed Beckman Deluxe Test Lead Accessory Kit comes in a handy case. The kit includes an assortment of probe tips for many applications. The kit includes the following tips: alligator clips, needle tips, and banana tips. All tips will screw into the Test Leads included with the kit.

BECKMAN

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MP MASTER
MA33124